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ONTARIO GEOLOGICAL SURVEY
Open File Report 5484

Sand and Gravel Resources of the Espanola Area District of Sudbury

by

Staff of the Engineering and Terrain Geology Section
Ontario Geological Survey

1983

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E.G. Pye, Director
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FOREWORD

The three townships surrounding the Town of Espanola (Nairn, Baldwin and Merritt Townships) contain numerous sand and gravel deposits which where laid down during glacial times. This report and its accompanying maps delineate these deposits and provide additional information regarding their thickness, geological character and suitability for use as construction aggregate. The report also indicates which deposits possess the greatest potential for resource utilization.

This report supplies valuable information which will be beneficial in resource planning.

V.G. Milne, Director
Ontario Geological Survey

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Abstract

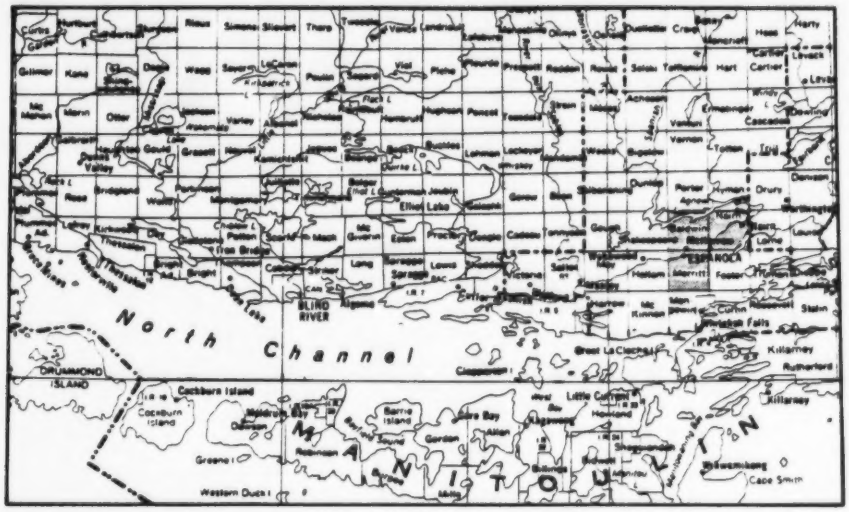

Figure 1 - Key Map Showing the Location of Nairn, Baldwin and Merritt Townships, Scale 1:1 584 000.

This report presents the results of a sand and gravel inventory in three townships surrounding the Town of Espanola in the District of Sudbury. Three Resource Areas of Primary Significance have been selected for possible resource protection. These areas contain the highest quality aggregate in the report area. Selected Sand and Gravel Resource Area 1 consists of four wave-modified ice-contact deposits and possesses the largest amount of crushable aggregate in the three townships. Selected Resource Areas 2 and 3 occupy part of the Spanish River valley outwash and contain sand and fine gravel. The three Resource Areas occupy 640 acres (260 ha), of which 520 acres (210 ha) are available for extraction. Total resources are 31 million tons (28 million tonnes). A number of Secondary Resource Areas have also been selected for possible protection. These areas contain minor amounts of crushable gravel and large amounts of material suitable for low-specification uses. The secondary areas can supply material for local demand.

Selected Resources Areas are not intended to be permanent, single, land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

Sand and Gravel Resources of the Espanola Area

Introduction[1]

The sand and gravel resources of Nairn, Baldwin and Merritt Townships were investigated by a two-man field party in the summer of 1983. This report presents the results of this study. Although the results of this work would normally be released in an Aggregate Resources Inventory Paper, the Open File Report format is used here in order to make this information available as quickly as possible. The purpose and methodology used to prepare this Report are essentially the same as is used for an Aggregate Resources Inventory Paper, and are presented in Appendix A. The format in which the information is presented on the maps is explained on the map legends and appendices.

Granular deposits related to glacial activity are widespread in these three townships, with sand as the dominant material. The Primary Resource Areas outlined later in the text include the deposits which contain the greatest amounts of gravel. Because gravel-bearing deposits are capable of being used for a wide range of aggregate products, the continued availability of these deposits is important. It is also important that planning strategies recognize the value of these areas in land use plans.

1. This project was jointly funded by Espanola District, Northeastern Region and the Aggregate Assessment Office, Engineering and Terrain Geology Section, Ontario Geological Survey.

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Location and Population

The Espanola Area lies approximately 65 km southwest of Sudbury in the southwestern part of the District of Sudbury. The report area consists of three townships: the incorporated townships of Nairn and Baldwin and the unorganized township of Merritt. The Town of Espanola lies within Merritt Township. The report area occupies approximately 62,916 acres (25 462 ha) and is found on the Espanola (41 I/5) and Whitefish Falls (41 W/4) map sheets of the National Topographic System, at a scale of 1:50 000.

The Town of Espanola is the major population centre in the area. In 1982, Espanola had a population of 5786, an increase of approximately 2.5 percent since 1972 (Ontario Ministry of Municipal Affairs and Housing 1983; Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1974). Nairn Township and Baldwin Township had populations in 1982 of 476 and 664, respectively (Ontario Ministry of Municipal Affairs and Housing 1983). The population in Nairn Township is concentrated in Nairn Centre, while the main population centre in Baldwin Township is McKerrow. Population figures for Merritt Township are unavailable.

Economic activity in the area is largely related to the forest industry. A large pulp and paper mill is located in Espanola and a sawmill operation in Nairn Centre. Tourism and recreation are also important to the local economy.

Access to the report area is provided by King's Highway 17 which runs east-west across the area, and King's Highway 6 which runs south from Espanola to Manitoulin Island and hence by ferry to the Bruce Peninsula. Several gravel-surfaced roads branch off these highways. Rail service is provided by the Canadian Pacific Railway which has tracks paralleling Highways 17 and 6.

Physiography and Surficial Geology

The glacial deposits in Nairn, Baldwin and Merritt Townships are underlain by Middle Precambrian bedrock, which also forms much of the area's ground surface. The bedrock consists of a complex array of sedimentary and intrusive rocks. The nature of these rocks has been described in detail by Card (1976; 1978), Card et al. (1977), Ginn (1965) and Thomson (1952). For further information on the bedrock geology of the area, the reader is referred to these reports. The bedrock is primarily responsible for the 'rock knob' physiography of the report area. This rock knob topography is found throughout the area; even in areas of thick glacial overburden, outcrops are common. This topography is largely caused by differential weathering between the various rock types, as well as erosion by the ice sheet as it moved over the area.

Glacial and postglacial materials make up the remainder of the land surface. These deposits are related to the last major advance and withdrawal of a continental ice sheet during the Late Wisconsinan Substage of the Pleistocene Epoch. Because of the general lack of glacial material in the region, the age relationships and origin of the various deposits are somewhat uncertain. A thin veneer of till appears to have been deposited on the bedrock surface as the ice sheet moved southwest over the area. Following the main glacial advance, the position of the ice front melted back to the north. During this waning stage of the ice, some small patches of gravelly ice-contact stratified drift were deposited on the southwest sides of the rock knobs. The largest ice-contact deposits are located in the north-central part of Baldwin Township.

As the ice front receded, large quantities of meltwater were released by the decaying ice and this water flowed south in meltwater channels towards the Lake Huron basin. The valley of the Spanish River acted as one of these channels. Sand and gravel outwash carried by the meltwater was deposited in the valley, and this material occupies a large area in Nairn Township and southern Baldwin Township. The Espanola townsite is also located on this sandy outwash. Meltwater in this channel flowed from northeast to southwest. As the distance from the meltwater source increased, the size of the sediment being deposited decreased. Consequently, the coarsest outwash is found in Nairn Township while the finest is located around Espanola.

As the ice front continued its retreat, meltwaters occupying the Lake Huron basin inundated the area. Wave action in this glacial lake removed much of the pre-existing till cover, leaving large areas of bare rock, and the material was reworked and deposited in areas of low elevation (Boissonneau 1968; Gartner 1980). These lacustrine deposits generally consist of fine sand, silt and clay and have thicknesses of approximately 5 feet (1.5 m). Lacustrine sand and silt overlie the Spanish River valley outwash as well as many other areas in the townships. The ice-contact deposits in north-central Baldwin Township were also modified by lacustrine action. This area is believed to have been an offshore bar in the glacial lake (Chapman, in Boissonneau 1968).

In the period since the disappearance of the ice sheet and the lowering of lake waters to present-day levels, postglacial activity has been minimal. Organic deposits have developed in depressions in the land surface, and some alluvial deposits have been laid down along water courses (Gartner 1980). South of Espanola, wind action has reworked fine lacustrine sand and silt into dunes.

Extractive Activity

At the time of field investigation, fifty-eight sand and gravel pits were identified and plotted on Map 1 and 2. Several other exposures were inspected, but as all these were very small, overgrown and long abandoned they were not included in the inventory. The fifty-eight identified pits were at various stages of development. Many pits had been inactive for a considerable period of time, while some had been worked recently. One pit contained portable screening equipment. Many of the pits, particularly in the southern part of the report area, were located in small deposits and were near depletion. Other pits had been opened to supply only low-specification borrow material. A small number of pits occupied several acres and supported commercial production on demand.

Extractive sites are spread throughout the report area, but there are four areas where they are concentrated: west of Nairn Centre; at the junction of Highway 17 and the Spanish River; on Hardwood Road in the north-central part of Baldwin Township; and in the southern part of the Town of Espanola.

Selected Sand and Gravel Resource Areas

Map 1 shows all the deposits containing sand and gravel in Nairn, Baldwin and Merritt Townships. Many of these deposits are unsuitable for extractive development for reasons of size, thickness and material quality. As a result, only the most significant sources are suggested for possible resource protection.

The selected sand and gravel resource areas are shown on Map 2. A total of three areas have been selected for resource protection at the primary level. Selected Sand and Gravel Resource Area 1 is composed of four wave-modified ice-contact deposits. The Area contains a significant amount of crushable gravel and represents the most important aggregate source in the report area.

Resource Areas 2 and 3 both consist of outwash deposited in the Spanish River valley, The deposits are generally sandy, but do contain fine to medium gravel.

The three Primary Resource Areas have a total acreage of 640 acres (260 ha). After accounting for cultural setbacks and previous extraction, approximately 520 acres (210 ha) are available for protection, containing resources of 31 million tons (28 million tonnes).

A number of secondary resource areas have also been selected for possible protection. In terms of aggregate quality, these deposits have less value for extraction than the primary areas, but they do provide important alternative sources, especially for local use. Some of the secondary deposits may also be capable of supplying small amounts of crushable gravel.

It is important to note that selected sand and gravel resource areas are not permanent, single land use units which must be incorporated into an official plan. They represent areas in which a major resource is believed to exist. Such resource areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

Selected Sand and Gravel Resource Area 1

Selected Sand and Gravel Resource Area 1 is located near Hardwood Road in north-central Baldwin Township. The Area consists of four wave-modified ice-contact deposits labelled 1a to 1d on Map 2.

Resource Area 1a has experienced the most extraction activity of the four deposits. Four large pits have been developed in Area 1a. Face heights ranged from 5 feet (1.5 m) in pit 28 up to 60 feet (18 m) in pit 29a. Gravel content in the exposures ranged from 30 to 50 percent. Pits 29b and 30 contained the greatest amounts of crushable gravel which was found in irregular beds in the lower part of the faces (e.g. Figure 3a). Silt seams and pockets of silty fine sand were common. The upper part of the faces in the pits contained sorted, stratified sand and fine gravel. Pit 29a primarily contained sand although gravelly bands were present. Shallow excavations in pit 28 exposed well sorted fine gravel with coarse sand. Data from the Ontario Ministry of Transportation and Communications (M.T.C.) indicate that material from this deposit is acceptable for use in granular base course, asphalt and concrete. Selection of material from the pit face and control of excess sand may be required to produce some higher quality products.

Resource Area 1a has an available acreage of 65 acres (26 ha). Assuming an average depth of 25 feet (8 m), available resources are estimated to be 4 million tons (4 million tonnes).

Resource Area 1b lies to the southwest of Area 1a. Exposures in this deposit revealed poorly sorted ice-contact material. Pits observed in the deposit had faces 20 to 45 feet (6 to 14 m) in height. Gravel content in the pits was as high as 70 percent, although some of the coarse material was composed of oversized boulders (greater than 4 inches or 10 cm) which require removal or processing before they can be utilized for aggregate. Because of the poorly sorted ice-contact nature of the deposit, material ranging in size from clay to boulders was observed.

Pit 31 had face heights ranging up to 45 feet (14 m) and gravel content was approximately 40 percent although in places it was as high as 70 percent. Silt was also noted in the pit. M.T.C. data indicate that the pit is capable of producing base course aggregate with sand control. Production of hot-laid asphalt aggregate may be prevented by lack of crushable material and excess fines.

Twenty-foot (6-m) faces in pit 32 contained approximately 60 percent gravel-sized aggregate, although 70 percent was reached in places (Figure 3a). Silt and clay seams were noted in the pit, and, in places, the gravel was clay coated; oversize boulders were also common. Some stockpiles were present in the pit. M.T.C. data indicate that material in the pit is suitable for granular base course with sand control and selection. Production of hot-laid asphalt aggregate requires selection and sand blending.

Resource Area 1b has an available area of 180 acres (73 ha), representing a resource tonnage of 11 million tons (10 million tonnes), based on an average thickness of 25 feet (8 m).

Area 1c is the smallest deposit in Resource Area 1. One pit (pit no. 33) located in the deposit was shallow, with a face height of only 10 feet (3 m), however 40 to 60 percent gravel was exposed. The face contained fine- to cobble-sized gravel with a silty sand matrix. Minor amounts of oversized material were present. A hammer seismic geophysics traverse was conducted near pit 33. The results of the test indicated that more granular material underlies the pit floor. Although there is no M.T.C. information for this deposit, it is similar in nature to the remainder of Area 1 and minor amounts of crushed aggregate could likely be produced with appropriate processing.

Resource Area 1c has an available area of 18 acres (7 ha). With an average deposit thickness of 15 feet (5 m), estimated resources are 1 million tons (1 million tonnes).

Resource Area 1d is the southernmost and least developed of the four deposits. No formal extraction has taken place in the deposit, although several small borrow pits were located during field examination. The small exposures revealed 40 to 50 percent gravel with coarse sand. The gravel in several areas was sufficiently large for crushing.

Resource Area 1d occupies an available area of 95 acres (38 ha). Assuming an average thickness of 15 feet (5 m), resources are estimated to be 4 million tons (4 million tonnes). Subsurface investigation would be valuable in augmenting the information currently available on this deposit.

In summary, Selected Sand and Gravel Resource Area 1 possesses the largest amount of crushable aggregate in the report area. Despite deleterious factors such as excess fines, oversize material and the need for special care in selection, sand control and blending, consideration should be given to protect as much of Area 1 as possible. Access to most of Area 1 is good, as provided by a gravel-surfaced road.

Selected Sand and Gravel Resource Area 2 and 3

Selected Sand and Gravel Resource Areas 2 and 3 are part of the extensive outwash deposit which occupies the Spanish River valley throughout the report area. The majority of the deposit is composed of well sorted coarse sand with minor amounts of inter-stratified fine gravel. Resource Areas 2 and 3 are very similar to the remainder of the deposit except that they contain slightly higher concentrations of gravel and so have been selected for resource protection at the primary level. Despite the higher percentage of gravel in the two areas, they are not considered as sources for crushable gravel because of the fine to medium size of the gravel. Several pits have been opened in these deposits and past extraction has been relatively extensive.

Resource Area 2 is located immediately west of Nairn Centre. Five pits have been opened in the deposit (pit nos. 4, 5, 6, 9 and 10). Pit nos. 4, 5, and 6 are located in the northern part of the deposit. Face heights in the pits range from 10 to 40 feet (3 to 12 m), and gravel content ranges from 10 to 50 percent. All of the pits have approximately 5 feet (1.5 m) of lacustrine fine sand at the top of the faces. Below the fine lacustrine sand, the faces expose chiefly coarse sand with fine to medium gravel found in interstratified bands and pockets within the sand. M.T.C. data for pit 5 indicate that the material can be used for granular sub-base and that the sand can be used in Hot-Laid No. 4 asphalt if it is blended with other fine aggregate.

Pits 9 and 10 are located in the southern end of the deposit. Faces are 10 to 25 feet (3 to 8 m) in height and contain 10 to 40 percent gravel (Figure 2a). Up to 10 feet (3 m) of lacustrine fine sand overlie the outwash sand and gravel. The crossbedded fine to coarse sand outwash in the faces was interlayered with fine gravel. In pit 9 minor amounts of gravel clasts reached sizes up to 4 inches (10 cm). M.T.C. data indicate that aggregate in pit 9 could be used for concrete and asphalt sand as well as granular sub-base. The material may also have value as blending sand.

Resource Area 3 lies just north of the point where Highway 17 crosses the Spanish River. Area 3 is also part of the Spanish River outwash. Three pits have been opened in the deposit (pit nos. 19, 20 and 21). Faces in the pits are shallow, ranging from 5 to 15 feet (1.5 to 5 m), but more material may be expected below the pit floors. The faces were predominantly sandy, with 5 to 35 percent of fine gravel. The gravel observed in the faces was found in thin seams interlayered with the often crossbedded medium to coarse sand. Gravel content of up to 50 percent was exposed in one face in pit 20 (Figure 3a). M.T.C. files indicate that material from pit 19 was used in the past for Granular Base Course B and C, as well as for winter ice control. The fine aggregate in this pit also has potential for use as asphalt sand if it is blended to produce a suitable gradation.

In general, the lack of coarse gravel prevents the deposit from being a source of crushable aggregate. The use of material in this Resource Area is thus restricted to relatively low-specification, pit-run aggregate. Another factor reducing the potential of the Resource Area is a relatively high water table; water was present on the floors of pit nos. 20 and 21 at the time of field investigation. In spite of these drawbacks, the Resource Area has value as a source of aggregate because of the scarcity of coarse material in the remainder of the report area.

Resource Areas 2 and 3 have available areas of 105 acres (42 ha) and 60 acres (24 ha), respectively. Assuming an average depth of 25 feet (8 m), resource tonnages are thus 7 million tons (6 million tonnes) and 4 million tons (4 million tonnes), respectively. Access to both Resource Areas via Highway 17 and gravel-surfaced roads is excellent.

Sand and Gravel Resource Areas of Secondary Significance

A number of deposits are recommended for resource protection at the secondary level. These deposits are limited for development by reasons of size, thickness and aggregate quality, but still have value for local use when low-specification aggregate is required close to a particular project or demand.

The small ice-contact deposit in southeastern Baldwin in which pit 35 is located has been selected for secondary resource protection. The size of the deposit has been limited by bedrock outcrops, and extraction has consumed much of the material, but small quantities of coarse aggregate remain. The field investigation of pit 35 noted faces of 40 to 60 feet (12 to 13 m) in part of the pit. Gravel content was irregular, but as high as 50 to 70 percent especially in the east end of the pit. Because of the ice-contract origin of the deposit, gravel distribution was irregular and silt seams as well as oversize boulders were present. M.T.C. data show that the material can be used for concrete, asphalt and granular base course aggregate. Because of excess fines and coarse gradation, blending is required for asphalt. Access is supplied by a secondary gravel road.

A buried ice-contact deposit in west-central Nairn Township is also selected for secondary resource protection. The deposit was laid down on the flanks of a rock outcrop and subsequently covered by up to 10 feet (3 m) of lacustrine silt and clay. The 5- to 25-foot (1.5- to 8-m) face in pit 18 revealed 40 to 50 percent fine to cobble-sized gravel with coarse sand and granules. Silt and minor oversize material were noted. Development of the pit is limited by its variability, overburden, thickness and poor access.

Two small ice-contact deposits in the southwestern part of Merritt Township are secondary resource areas. Pit 56 is located in the westernmost deposit. Material in the pit shows the variability typical of ice-contact deposits, ranging from silt (in seams) to oversize boulders. Face heights are up to 30 feet (9 m) in places with gravel content ranging from 40 to 70 percent (Figure 4a). Depth of the deposit is irregular, as indicated by a metagabbro rock knob protruding into the pit. Crushable aggregate could be produced from the deposit with selection. A stockpile of crushed gravel was present at the site.

Pit 57 is located in the other ice-contact deposit. The material which is nearly depleted is draped on the side of a rock outcrop. The 10- to 20-foot (3- to 6-m) exposure reveals 60 to 70 percent fine to cobble-sized gravel (Figure 4a). Minor silt was also present. Although near depletion, small quantities of crushable aggregate could still be produced from this deposit.

The remaining secondary resource areas consist of several sections of the Spanish River valley outwash deposit which are located close to Selected Resource Areas 2 and 3. Several pits have been opened in these deposits along Highway 17, west of Nairn Centre. The material in the pits is very similar to that in Resource Areas 2 and 3, but there is a lower percentage of gravel. In the generally shallow pits, gravel is found in thin bands interlayered with coarse sand. Gravel content in the pits is generally less than 10 percent. M.T.C. data for some pits in the area indicate the material is suitable for granular sub-base, asphalt sand (with blending) and ice-control sand. Much of this secondary outwash material is well situated, with respect to access, along Highway 17.

Two deposits of the Spanish River outwash, selected for secondary protection, are located on the north side of the Spanish River, north of Nairn Centre. Extraction in these deposits has taken place in only one pit (pit no. 2), so limited information is available. Faces in pit 2 reveal gravel seams interlayered within medium to coarse sand. One drilled test hole (ESP-TH-2) and field observations supply some further data (Table 4 and Figures 5a and 5b). The test hole revealed sand, with fine gravel at depth (generally below 11 feet (3 m)). Field observations noted the presence of gravelly pockets in the deposits. Since this material was deposited closer to the melting ice front than the deposits to the southwest, it is expected to be somewhat coarser. Sufficient coarse aggregate may be found to make the long haul distance to Highway 17 economic.

Sand and Gravel Resources of Tertiary Significance

The remaining resources in the area are primarily sandy outwash or sandy lacustrine deposits, and are classified at the tertiary level. The outwash sand is generally very fine and well sorted while the lacustrine sand is also fine and frequently silty. Because the sand is excessively fine and poorly graded, the use of these deposits is generally limited to borrow material or fill. M.T.C. data for a limited number of pits in these areas indicate that, for the most part, the material is unsuited for use in engineered products.

Despite these drawbacks, the deposits may have importance when short haul distances are of more importance than material quality. The numerous pits developed on the fringes of the Espanola townsite give evidence of such situations.

Summary

Sand and gravel deposits in the Espanola Area are the result of glacial activity. The report area has large quantities of sand but only limited amounts of coarse material. Three areas have been selected for possible resource protection at the primary level. Resource Area 1 is the most important source of crushable aggregate in the study area. Resource Areas 2 and 3 are capable of supplying low-specification aggregate products. A number of secondary resource areas are capable of supplying minor amounts of crushable gravel and large quantities of low-specification aggregate.

Enquiries regarding the aggregate inventory of Nairn, Baldwin and Merritt Townships should be directed to the Ontario Ministry of Natural Resources either at the Espanola District Office, Box 1340, 148 Fleming St., Espanola, Ontario, P0P 1C0 (Tel. 705-869-1330) or at the Northeastern Regional Office, 199 Larch St., Sudbury, Ontario, P3E 5P9 (Tel. 705-675-4120).

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, ESPANOLA AREA

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix D)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
1	G-IC	115 (46)	9 (8)
	G-IC-LB	300 (121)	19 (17)
	G-OW-LP	220 (89)	14 (13)
	S-LP	110 (44)	6 (5)
	S-OW-LP	11,300 (4550)	710 (640)
	S-OW-LP-WD	760 (310)	48 (44)
2	G-IC	115 (46)	4 (4)
	G-IC-LB	120 (49)	4 (4)
	S-LP	2190 (890)	82 (74)
	S-OW-LP	1080 (435)	40 (36)
3	S-IC-LB	75 (30)	2 (2)
	S-LB	10 (4)	<1 (<1)
	S-LP	680 (275)	14 (13)
	S-OW-LP	250 (101)	5 (4)
4	S-LP	65 (26)	1 (1)
		17,400 (7000)	960 (870)

N.B. Minor variations in all tables are caused by rounding of data.

TABLE 2 | SAND AND GRAVEL PITS, ESPANOLA AREA

1 NO.	2 LOT	3 CON.	4 FACE HEIGHT Feet (Metres)	5 % GRAVEL	6 REMARKS
Nairn Township					
1	9	6	5-30 (1.5-9)	variable	ice-contact, clay to coarse gravel
2	5	5	5-15 (1.5-5)	15-25	medium to coarse sand with gravel
3	3	5	5-10 (1.5-3)	25-40	lacustrine (lac.) clay at top of face
4	4	4	15-20 (5-6)	40-50	now landfill, lac. sand at top
5	4	4	20-40 (6-12)	10-40	sand with gravel pockets
6	3	4	10-40 (3-12)	25-30	fine gravel, lac. sand at top
7	3	4	10-20 (3-6)	sand	
8	3	4	10-15 (3-5)	sand	fine gravel on pit floor
9	4	4	20-25 (4-8)	10-30	fine gravel in lower face
10	4	4	10-25 (3-8)	25-40	fine gravel, lac. sand at top
11	5	4	15-25 (5-8)	5	fine gravel in pockets
12	5	4	2-3 (0.6-1)	sand	
13	7	3	3 (1)	sand	
14	7	4	30-35 (9-11)	5	
15	5	4	10 (3)	20-30	fine gravel
16	5	4	30 (9)	30-40	fine gravel

TABLE 2 | SAND AND GRAVEL PITS. ESPANOLA AREA

1 NO.	2 LOT	3 CON.	4 FACE HEIGHT Feet (Metres)	5 % GRAVEL	6 REMARKS
17	12	4	10-12 (3-4)	50-60	ice-contact, oversize, lac. silt at top
18	12	4	5-25 (1.5-8)	40-50	fine to cobble gravel, lac. silt at top
19	11	3	5-7 (1.5-2)	20-35	gravelly seams
20	11	3	10-15 (3-5)	15-20	one gravelly face
21	11	2	6 (2)	5	fine gravel
22	11	2	5 (1.5)	sand	
23	11	2	5-10 (1.5-3)	5-10	
24	10	2	6 (2)	5	fine gravel
25	12	2	5-8 (1.5-2)	sand	
26	11	2	15 (5)	5-10	fine gravel in top of face
Baldwin Township					
27	7	6	up to 40 (12)	30-60	beach gravel on bedrock knob
28	7	5	5 (1.5)	35-40	wave-washed ice-contact gravel
29a	7	5	30-60 (9-18)	30	chiefly sand
29b	7	5	35 (11)	40-50	ice-contact gravel, crushable
30	7	5	30-40 (9-12)	30-40	ice-contact, selection required
31	8	4	40-45 (12-14)	40-70	ice-contact, crushable

TABLE 2 | SAND AND GRAVEL PITS, ESPANOLA AREA

1 NO.	2 LOT	3 CON.	4 FACE HEIGHT Feet (Metres)	5 % GRAVEL	6 REMARKS
32	8	4	20 (6)	60-70	crushable, oversize and fines
33	9	3	10 (3)	40-60	ice-contact, crushable, minor oversize
34	6	3	3-7 (1-2)	sand	
35	3	3	40-60 (12-18)	50-70	ice-contact, crushable, thin lac. sand at top
36	6	2	5 (1.5)	sand	
37	8	1	3 (1)	sand	
Meritt Township					
38	8	6	up to 60 (18)	50 variable	ice-contact, incl. till and gravel pockets
39	1	6	5-8 (1.5-2)	30-50	fine gravel, lac. sand at top
40	10	6	5-10 (1.5-3)	sand	
41	12	5	5 (1.5)	sand	
42	12	5	10 (3)	sand	lac. silt at top
43	10	5	3-5 (1-1.5)	sand	
44	10	5	3 (1)	sand	
45	9	5	5-8 (1.5-2)	sand	
46	11	4	5-12 (1.5-4)	sand	dune sand
47	11	4	5-12 (1.5-4)	sand	dune sand

TABLE 2 | SAND AND GRAVEL PITS, ESPANOLA AREA

1 NO.	2 LOT	3 CON.	4 FACE HEIGHT Feet (Metres)	5 % GRAVEL	6 REMARKS
48	9	4	5-20 (1.5-6)	sand	dune sand
49	8	4	3-8 (1-2)	sand	
50	7	4	3 (1)	5	
51	5	4	5 (1.5)	5-10	gravel at top of face
52	4	4	50-60 (15-18)	40-50 variable	depleted, ice-contact on rock knob
53	6	3	up to 50 (15)	variable	pockets of ice-contact gravel
54	11	3	-	-	
55	11	3	30-35 (9-11)	up to 50	gravel near top of face, lac. silt and clay at top
56	12	2	10-30 (3-9)	40-70	crushable, ice-contact on rock knob
57	10	2	10-20 (3-6)	60-70	crushable ice-contact
58	11	2	7 (2)	5	irregularly bedded sand with silt and gravel seams

TABLE 3 | SELECTED SAND AND GRAVEL RESOURCE AREAS, ESPANOLA AREA

1	2	3	4	5	6	7
Deposit No.	AREA Acres (Hectares)	CULTURAL SETBACKS Acres (Hectares)	EXTRACTED AREA Acres (Hectares)	AVAILABLE AREA Acres (Hectares)	ESTIMATED DEPOSIT THICKNESS Feet (Metres)	AVAILABLE AGGREGATE Millions of Tons (Tonnes)
1a	100 (40)	22 (9)	13 (5)	65 (26)	25 (8)	4 (4)
1b	200 (81)	15 (6)	5 (2)	180 (73)	25 (8)	11 (10)
1c	20 (8)	0 (0)	2 (1)	18 (7)	15 (5)	1 (1)
1d	100 (40)	0 (0)	5 (2)	95 (38)	15 (5)	4 (4)
2	140 (57)	20 (8)	15 (6)	105 (42)	25 (8)	7 (6)
3	80 (32)	11 (4)	9 (4)	60 (24)	25 (8)	4 (4)
	640 (260)	68 (28)	49 (20)	520 (210)		31 (28)

TABLE 4 - SUMMARY OF TEST HOLE DATA, ESPANOLA AREA

TEST HOLE NUMBER: ESP-TH-1

LOCATION: Lot 4, Conc. 6, Merritt Township

ELEVATION: Approximately 620 feet (189 m) a.s.l.

DATE: Sept. 1, 1983

DEPTH feet (metres)	DESCRIPTION
0-5.0 (0-1.5)	fine sand
5.0-8.0 (1.5-2.4)	fine to medium sand
8.0-11.0 (2.4-3.4)	fine to medium sand with some granules
11.0-23.0 (3.4-7.0)	fine to medium sand

TEST HOLE NUMBER: ESP-TH-2

LOCATION: Lot 6, Conc. 5, Nairn Township

ELEVATION: Approximately 830 feet (253 m) a.s.l.

DATE: Sept. 2, 1983

DEPTH feet (metres)	DESCRIPTION
0-11.0 (0-3.4)	coarse sand with some fine gravel
11.0-14.0 (3.4-4.3)	coarse sand with granules and some fine gravel
14.0-20.0 (4.3-6.1)	coarse sand with fine gravel
20.0-23.0 (6.1-7.0)	coarse sand with fine to medium gravel

TEST HOLE NUMBER: ESP-TH-3

LOCATION: Lot 5, Conc. 4, Nairn Township

ELEVATION: Approximately 710 feet (216 m) a.s.l.

DATE: Sept. 2, 1983

DEPTH feet (metres)	DESCRIPTION
0-5.0 (0-1.5)	fine to coarse sand with granules and some fine gravel
5.0-8.0 (1.5-2.4)	fine to coarse sand with granules
8.0-11.0 (2.4-3.4)	fine to coarse sand with some granules
11.0-14.0 (3.4-4.3)	medium to coarse sand with granules
14.0-17.0 (4.3-5.2)	medium to coarse sand with some granules
17.0-26.0 (5.2-7.9)	fine to coarse sand with some granules
26.0-29.0 (7.9-8.8)	medium to coarse sand with granules and some fine gravel

TEST HOLE NUMBER: ESP-TH-4

LOCATION: Lot 8, Conc. 5, Baldwin Township

ELEVATION: Approximately 980 feet (299 m) a.s.l.

DATE: Sept. 3, 1983

DEPTH feet (metres)	DESCRIPTION
0-5.0 (0-1.5)	fine sand; auger is pushing some coarse material to side of hole
5.0-8.0 (1.5-2.4)	fine sand
8.0-11.0 (2.4-3.4)	wet fine sand
12.0 (3.7)	auger hit bedrock or boulder

TABLE 5 - SUMMARY OF GEOPHYSICS DATA, ESPANOLA AREA

Baldwin Township

Line Number: ESP-GT-1

Line Direction: North-South

Method: Hammer Seismic

Location: Lot 9, Conc. 3

Elevation: Approximately 925 feet (282 m) a.s.l.

Seismic Data: Number of Layers - 3

Layer Velocities - Layer 1 = 1450 ft/sec. (442 m/sec.)

Layer 2 = 3070 ft/sec. (936 m/sec.)

Layer 3 = 1333 ft/sec. (406 m/sec.)

Interpretation - Approximately 3 feet (1 m) of stratified sand, overlying sandy silt or gravel, overlying sand.

Line Number: ESP-GT-2

Line Direction: Northeast-Southwest

Method: Hammer Seismic

Location: Lot 10, Conc. 3

Elevation: Approximately 975 feet (297 m) a.s.l.

Seismic Data: Number of Layers - 2

Layer Velocities - Layer 1 = 1560 ft/sec. (475 m/sec.)

Layer 2 = 3800 ft/sec. (1158m/sec.)

Interpretation - Approximately 2 feet (0.6 m) of sand, overlying sand and gravel, overlying an irregular bedrock surface.

Line Number: ESP-GT-3

Line Direction: East-West

Method: Hammer Seismic

Location: Lot 8, Conc. 5

Elevation: Approximately 975 feet (297 m) a.s.l.

Seismic Data: Number of Layers - 2

Layer Velocities - Layer 1 = 1250 ft/sec. (381 m/sec.)

Layer 2 = 11,500 ft/sec. (3505 m/sec.)

Interpretation - Approximately 10 feet (3 m) of wet sand overlying an irregular bedrock surface.

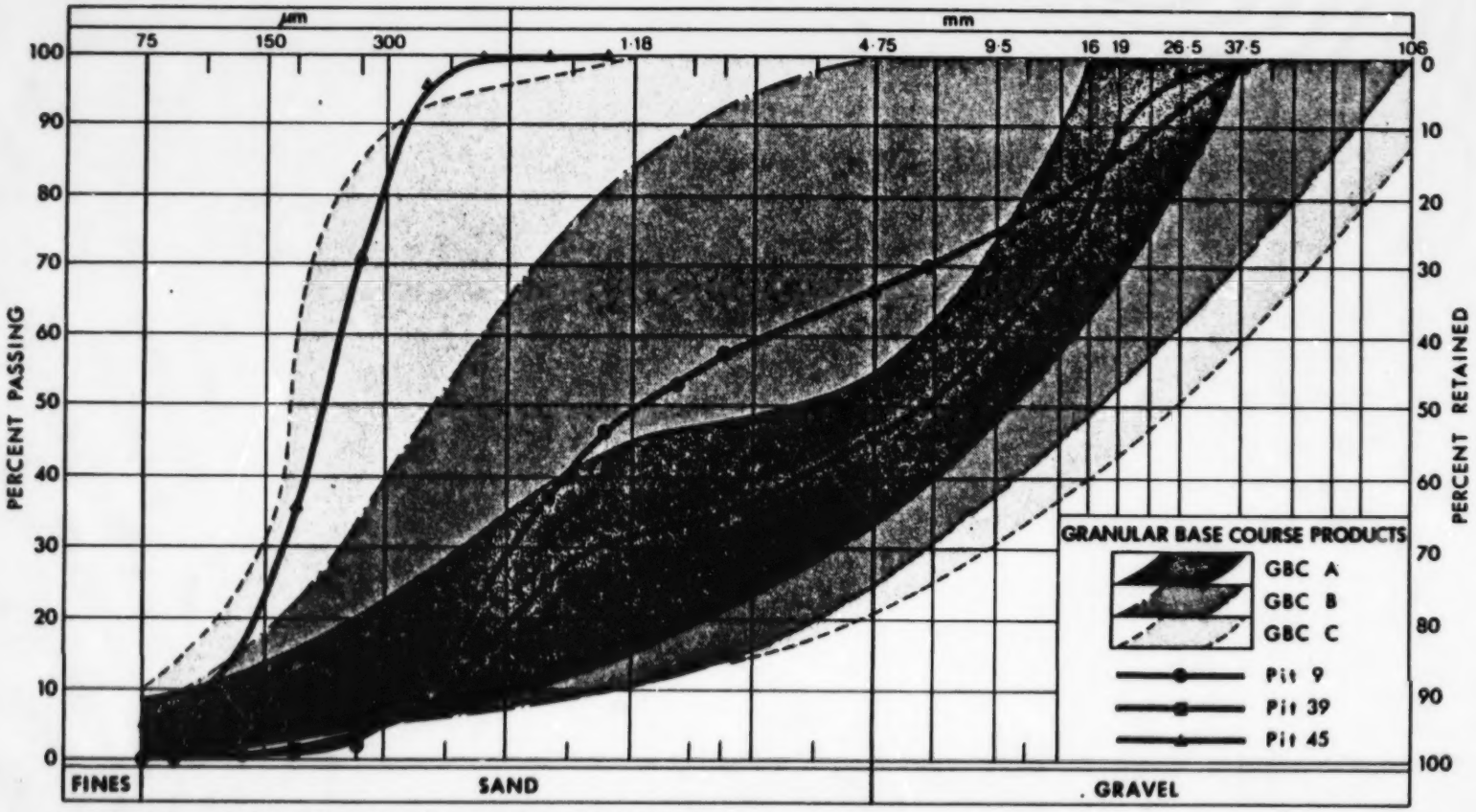

FIGURE 2a: AGGREGATE GRADING CURVES, ESPANOLA AREA:

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

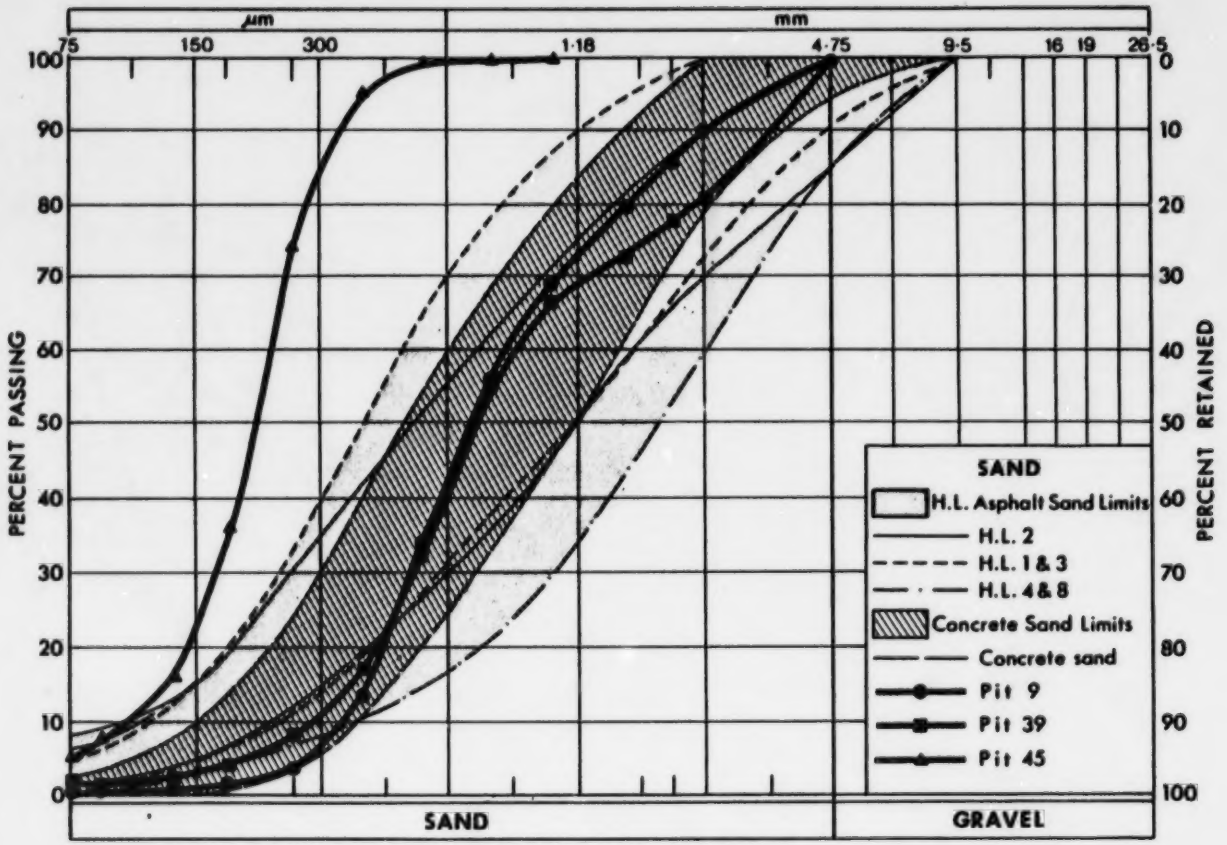

FIGURE 2b: AGGREGATE GRADING CURVES, ESPANOLA AREA:

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

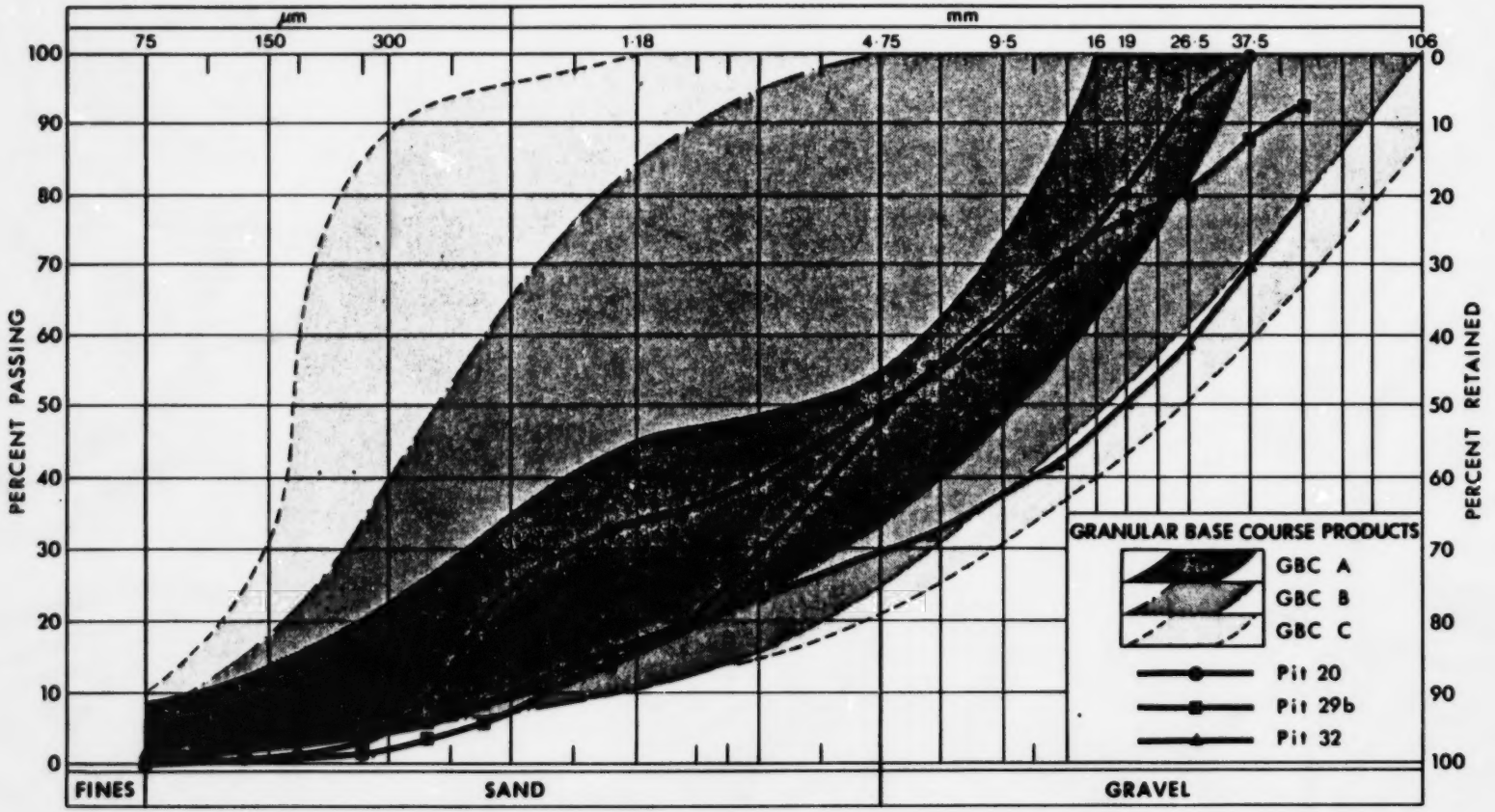

FIGURE 3a: AGGREGATE GRADING CURVES, ESPANOLA AREA:

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

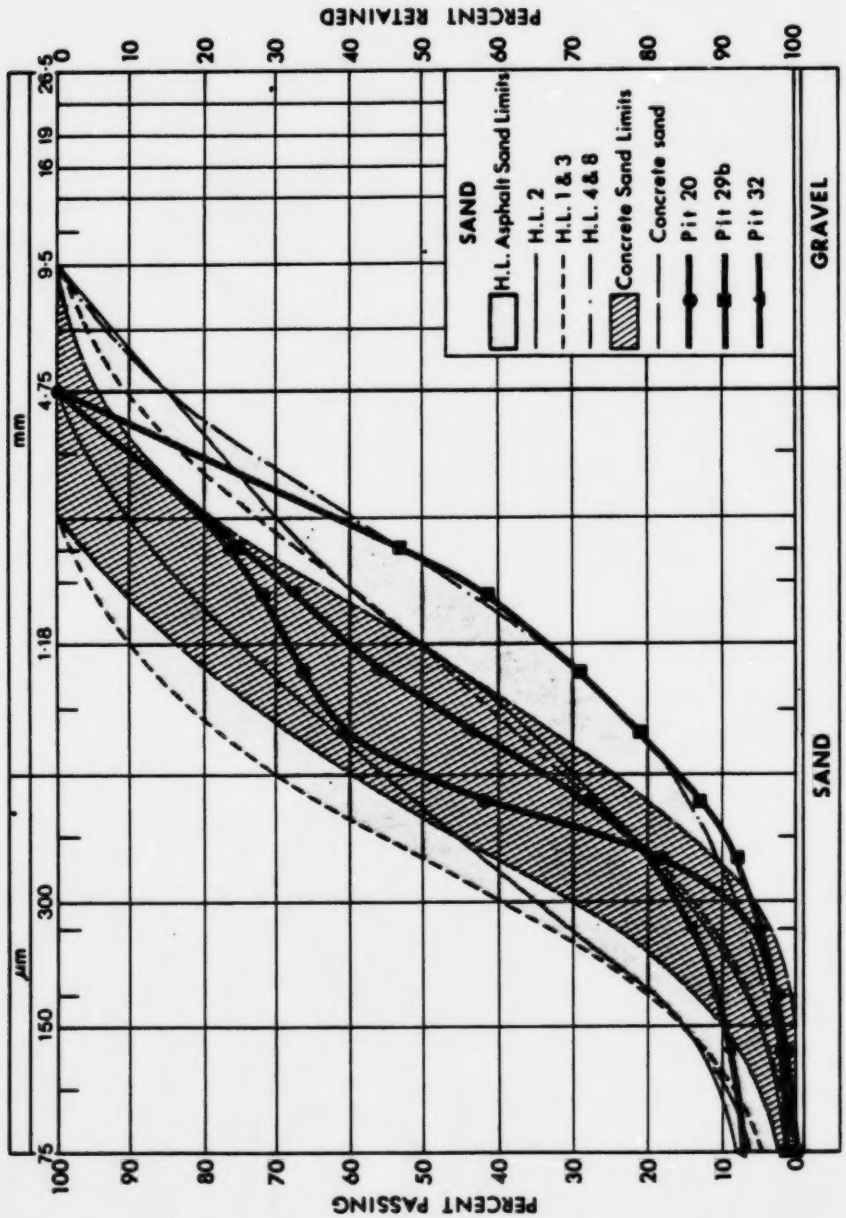

FIGURE 3b: AGGREGATE GRADING CURVES, ESPANOLA AREA:

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

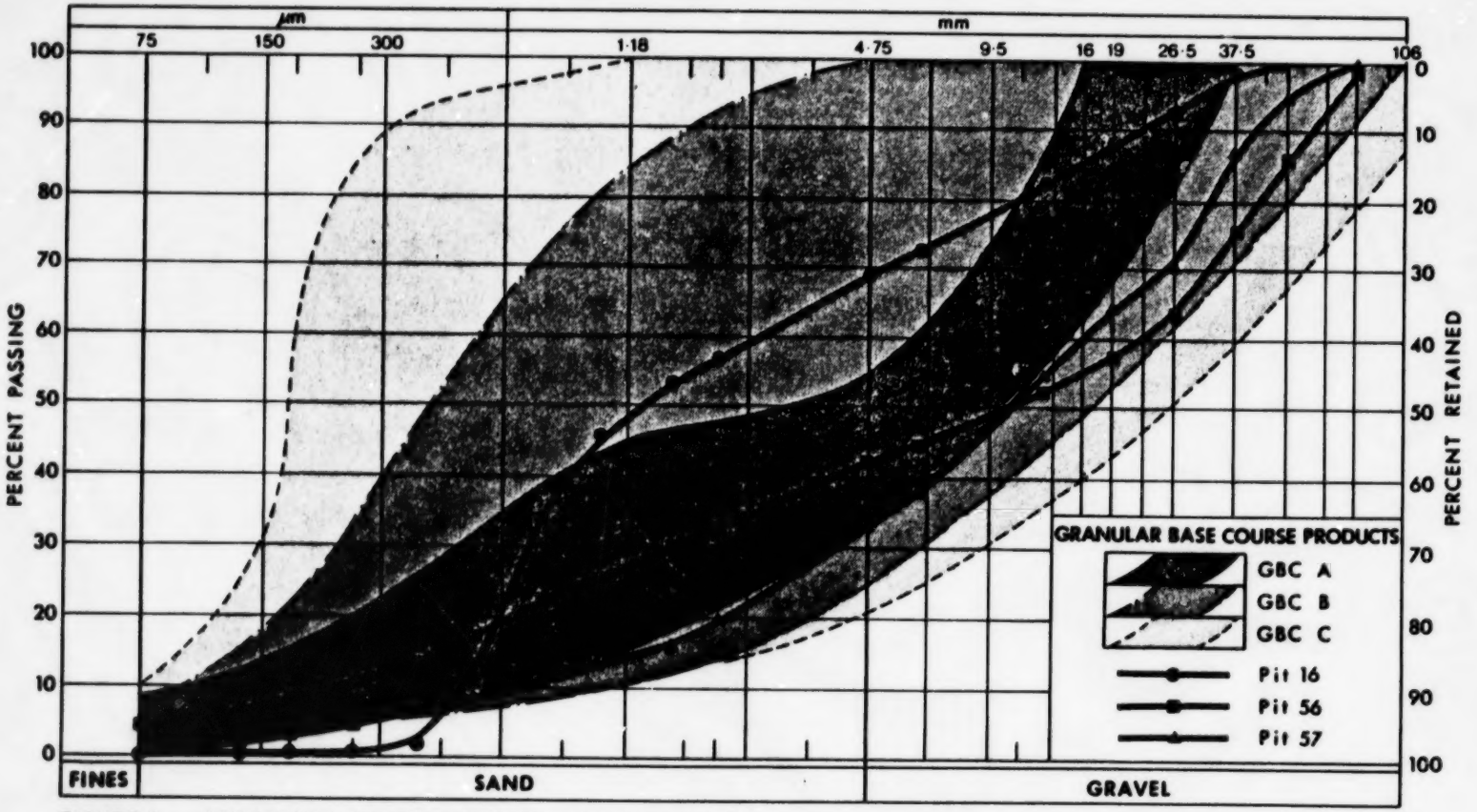

FIGURE 4a: AGGREGATE GRADING CURVES, ESPANOLA AREA:

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

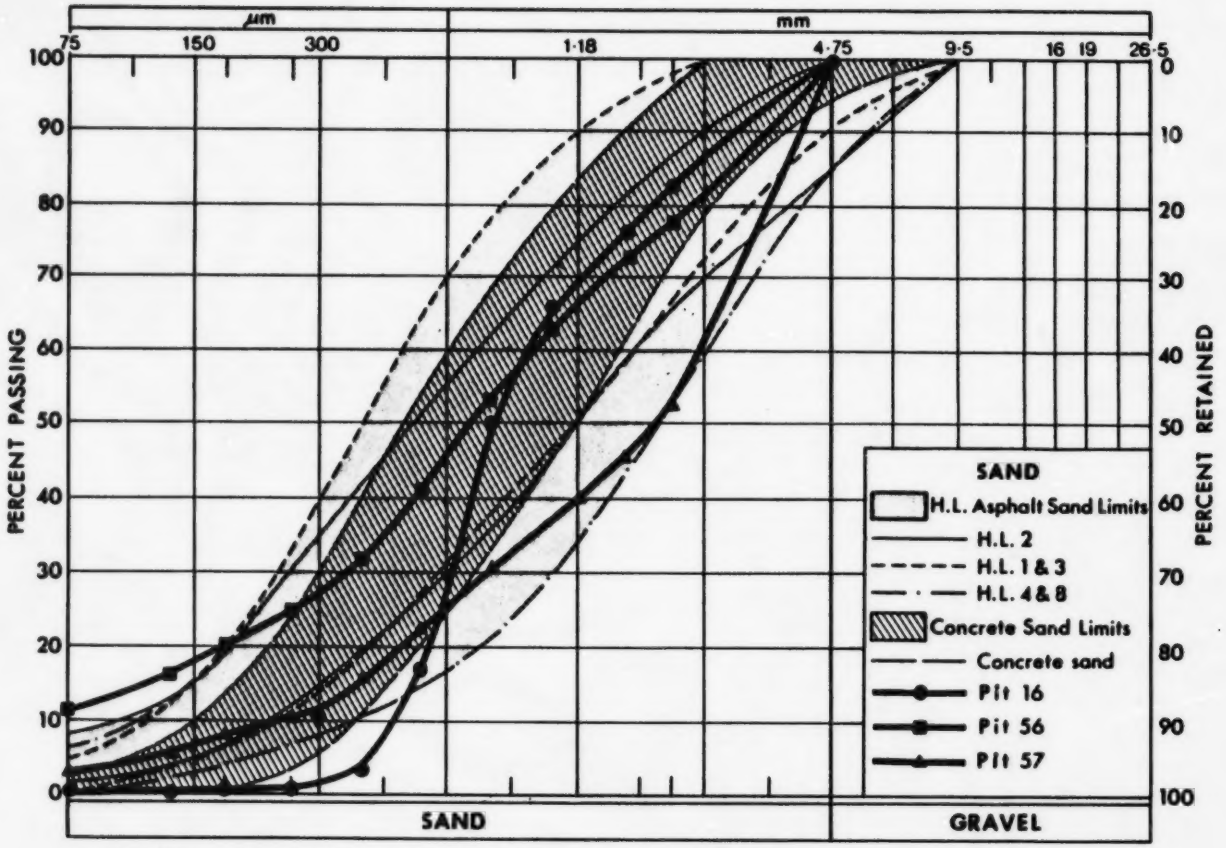

FIGURE 4b: AGGREGATE GRADING CURVES, ESPANOLA AREA:

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

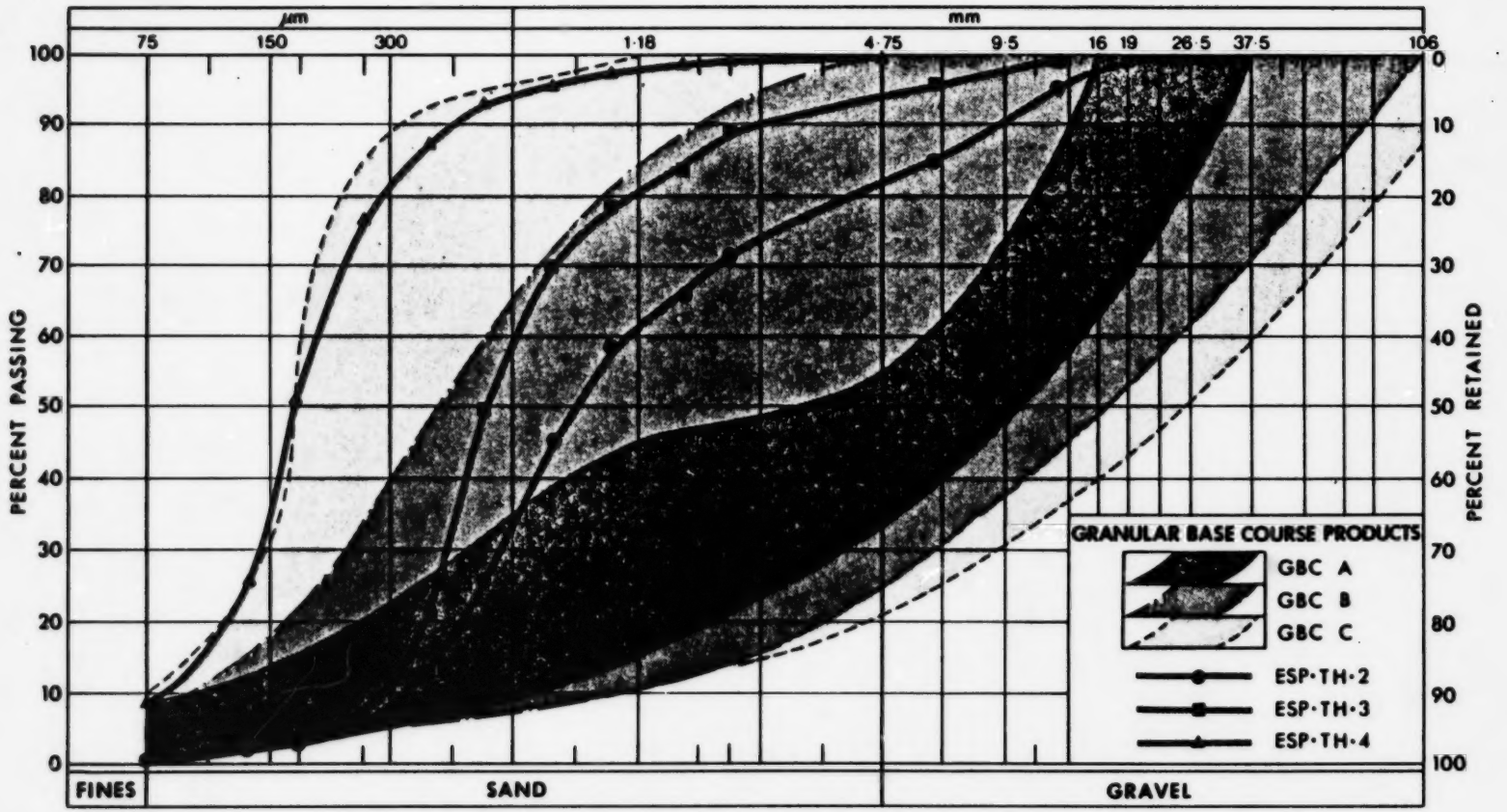

FIGURE 5a: AGGREGATE GRADING CURVES, ESPANOLA AREA:

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

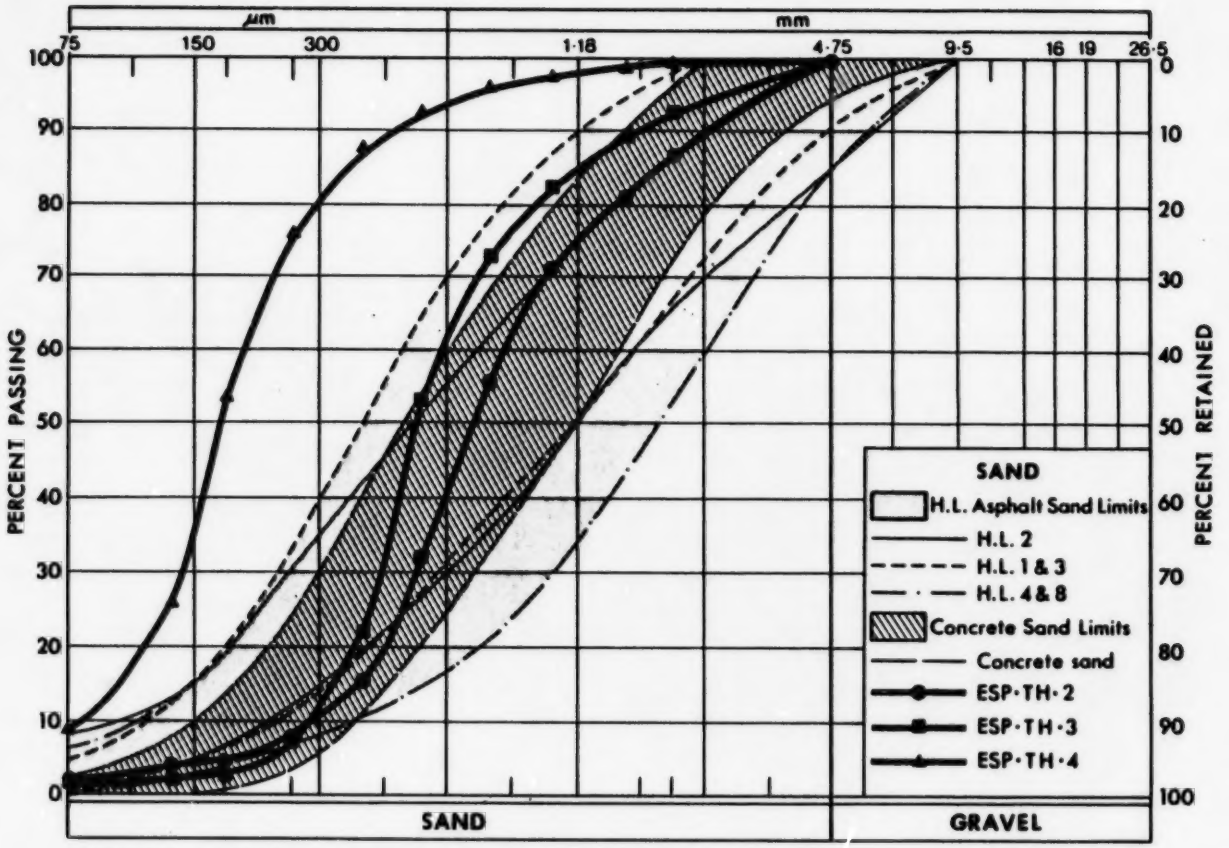

FIGURE 5b: AGGREGATE GRADING CURVES, ESPANOLA AREA:

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

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APPENDIX A - PURPOSE, METHODOLOGY AND DATA PRESENTATION OF THE AGGREGATE RESOURCES INVENTORY*

INTRODUCTION

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1980, the total tonnage of mineral aggregate extracted was 171 million tons (155 million tonnes), greater than that of any other metallic or nonmetallic commodity mined in the Province (Ontario Ministry of Natural Resources 1981).

Although mineral aggregate deposits are plentiful in Ontario, they are fixed-location, nonrenewable resources which can be exploited only in those areas where the deposits occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to a market area, as well as its quality and size. The potential for extractive development is usually greatest in urban fringe areas where land use competition is extreme. For these reasons, the availability of adequate resources for future development is now being threatened in some areas.

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*This Appendix is made up of the standard Introduction and Part I and II from the Aggregate Resources Inventory Paper (ARIP) series (for example, see ARIP 89, Aggregate Resources Inventory of the Central Part of the City of Timmins). The text has been modified slightly to correspond to the data presented in this Open File Report. The methodology and data presentation used in this OFR are identical to those used in the ARIP Series.

Comprehensive planning and resource management strategies are required to make the best use of available resources. Such strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies and official plans. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision-makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of a municipality's resources.

The report includes an assessment of all the sand and gravel resources in the study area. The most recent information available has been used to prepare the report. As new information becomes available, revisions may be necessary.

PART I - INVENTORY METHODS

FIELD AND OFFICE METHODS

The methods used to prepare the report involved the interpretation of published geological data such as bedrock and surficial geology maps and reports (see References), as well as field examination of potential resource areas. Field methods included the examination of natural and man-made exposures of granular material. Observations were made at sand and gravel pits located from records held by the Ontario Ministry of Transportation and Communications (M.T.C.), the Ontario Geological Survey, and by Regional and District Offices of the Ontario Ministry of Natural Resources. Observations made at pit sites included estimates of the total face height and the proportion of gravel- and sand-sized fragments in the deposit. Observations were also made of the shape and lithology of the particles. These characteristics are important in estimating the quality and quantity of the aggregate. In areas of limited exposure, drilling and hammer seismic geophysical techniques were used to assess subsurface materials. Airphotos were used to determine the continuity of deposits, especially in areas of limited information.

Deposits with potential for further extractive development or those where existing data are scarce, were studied in greater detail. Representative layers in these deposits were sampled in 25- to 100-pound (11- to 45-kg) units from existing pit faces. The samples were analyzed for grain size distribution. In areas of limited subsurface exposure, geophysical surveys and subsurface drilling were undertaken. The geophysical survey consisted of the use of a portable hammer seismic unit. Subsurface drilling was carried out by a portable auger drilling machine equipped with 2-inch (5-cm) solid stem augers. The location of test holes and geophysical traverse lines are shown on Map 1. Logs with stratigraphic descriptions of test holes and seismic lines are enclosed in the tables.

In the office, the field data were supplemented by pit information on file with the Engineering Materials Office of the Ontario Ministry of Transportation and Communications. Data contained in these files include field estimates of the depth, composition and "workability" of deposits, as well as laboratory analyses of the physical properties and chemical suitability of the aggregate. Information concerning the development history of the pits and acceptable uses of the aggregate is also recorded. The locations of additional sources were obtained from records held by Regional and District Offices of the Ontario Ministry of Natural Resources. The cooperation of the above-named groups in the compilation of inventory data is gratefully acknowledged.

Water well records, held by the Ontario Ministry of the Environment, were referred to at the preliminary assessment stage to identify areas of possible buried granular material. These records were used in conjunction with other evidence. Topographic maps of the National Topographic System, at a scale of 1:50 000, were used as a compilation base for the field and office data. The base map was prepared by the Cartography Section of the Lands and Waters Group, Ontario Ministry of Natural Resources, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

Sand and Gravel Resources

Once the interpretative boundaries of the aggregate units have been drawn, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows: First, the area of the deposit, as outlined on the final base map, is calculated in acres. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in

the deposit or on subsurface data such as water well logs. Original tonnage values can then be calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot (0.3-m) thick layer of sand and gravel, one acre (0.4 ha) in extent, assuming an average density of 110 pounds per cubic foot (1766 kg per cubic metre).

Tonnage = Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e. original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 are calculated in the following way. Two successive subtractions are made from the total area. Column 3 accounts for the number of acres unavailable due to the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas that have previously been extracted (e.g. wayside pits are included in this category). The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factor (Column 5 x Column 6 x 2500) to give an estimate of the sand and gravel tonnage presently available for extractive development and/or resource protection.

Reserve estimates are calculated for deposits of primary significance. Reserve estimates for deposits of secondary and tertiary significance are not calculated in Table 3, however, the aggregate potential of these deposits is discussed in the report.

UNITS AND DEFINITIONS

Although most of the measurements and other primary data available for resource tonnage calculations are given in Imperial units, Metric units have also been given in the text and on the tables which accompany the report. The Metric equivalent of the data is shown in brackets after or directly below the corresponding Imperial figures. Data are generally rounded off in accordance with the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel are termed possible resources in accordance with terminology of the Ontario Resources Classification Scheme (Robertson 1975, p. 7) and with the Association of Professional Engineers of Ontario (1976).

PART II - DATA PRESENTATION AND INTERPRETATION

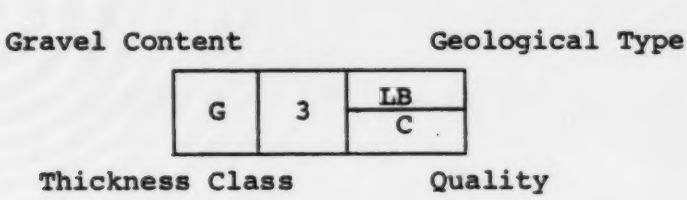
There are two maps, each portraying a different aspect of the aggregate resources in the report area. Map 1, "Distribution of Sand and Gravel Deposits", gives a comprehensive inventory of the sand and gravel resources in the report area. Map 2, "Selected Sand and Gravel Resource Areas", shows those deposits which are considered to represent the largest and/or highest quality resources in the area.

MAP 1: DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

Map 1 is derived directly from existing surficial geology maps or from airphoto interpretation in areas where mapping is incomplete. The map represents a comprehensive inventory of sand and gravel deposits within the project area and serves as a base for the calculation of total sand and gravel resources. The map also represents a summary of all available information related to the quality of aggregate in the mapped deposits. Much of this information is contained in two symbols which appear on the map. The Deposit Symbol appears for each mapped deposit and summarizes important genetic and textural data. The Texture Symbol is a circular porportional diagram which displays the grain size distribution of the aggregate in areas where bulk samples were taken.

Deposit Symbol

The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type), and quality limitations for every deposit shown on Map 1. These components are illustrated by the following example:



This symbol identifies a lacustrine beach deposit 5 to 10 feet (1.5 to 3 m) thick containing more than 35 percent unprocessed gravel. Excess fines may limit uses of the aggregate in the deposit.

The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S" indicates that the deposit is generally "sandy" and that gravel-sized aggregate makes up less than 35 percent of the whole deposit. The "G" indicates that the deposit probably contains more than 35 percent gravel.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Map 1.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identifies the geologic deposit type (the types are summarized with respect to their main geologic and extractive characteristics in Appendix D) and the lower series of letters identifies the main quality limitations that may be present in the deposit as discussed in the next section.

Texture Symbol

The Texture Symbol provides a more detailed assessment of the grain size distribution in deposits where samples were taken during field study. The data from which these symbols are derived has been plotted on grain size distribution graphs. The relative amounts of gravel, sand, and fines in the sampled material are shown graphically by the subdivision of a circle into proportional segments.

Other information shown on Map 1 are test hole locations, indicated by a solid drillhole symbol. In addition, all known sand and gravel pits, whether presently active or inactive, are shown by a dot symbol and a number which refers to the pit descriptions given in Table 2. Each description notes the location of the pit and the estimated face height and gravel content.

MAP 2: SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 2 is an interpretative map derived from an evaluation of the deposits shown on Map 1. The deposits identified on Map 2 are those which are considered to be important in ensuring an adequate resource base for the future.

All the selected sand and gravel resource areas are first delineated by geological boundaries and then classified into three levels of significance: primary, secondary and tertiary. These areas are identified on Map 2 by different shading patterns.

Each area of primary significance is assessed as to its probable relative value as a resource in the municipality and is given a deposit number which denotes its ranking order in that municipality. All such deposits are shown by a dark tone on Map 2.

Selected Sand and Gravel Resource Areas of primary significance are not permanent, single, land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such resource areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

Deposits of secondary significance are not ranked numerically, but are indicated by a light tone on Map 2. Such deposits are believed to contain significant amounts of sand and gravel. Although deposits of secondary significance are not considered to be the "best" resource areas, they may contain large quantities of sand and gravel and should be considered as part of the aggregate supply of the municipality.

Areas of tertiary significance are outlined on the map by a solid line, but have no tone. They are neither rated nor considered to be important resource areas, because of their low available resources or because of possible difficulties in extraction. Such areas may be useful for local needs, but are unlikely to support large-scale development.

The process by which deposits are evaluated and selected involves the consideration of two sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selction of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity, and distribution of resources in the region in which the municipality is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

SITE SPECIFIC CRITERIA

Deposit Size

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall reserves in the rest of the municipality. Generally, deposits in Class 1, i.e. those thicker than 20 feet (6 m) and containing more than 35 percent coarse aggregate larger than the No. 4 (4.75 mm) sieve are considered to be most favourable for commercial development. Thinner deposits may be valuable in municipalities with low total resources.

Aggregate Quality

The limitations of natural aggregate for various uses result from variations in the lithology of the particles making up the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the symbol for each deposit on Map 1. They are: Gravel content (G or S), fines (C), oversize (O) and lithology (L).

Three of the indicators deal with grain size distribution. The "gravel content", (G or S), indicates the suitability of aggregate for various uses. Deposits containing more than 35 percent coarse aggregate larger than the No. 4 (4.75 mm) sieve, and also a minimum of 20 percent larger than the 1 inch (25 mm) sieve, are considered to be favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess "fines" (high silt and clay content) may severely limit the potential use of an aggregate. Fines content in excess of 10 percent may impede drainage in road sub-base aggregate and render it more susceptible to the effects of frost action. In asphalt aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fines content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20 percent "oversize" material (greater than 4 inches (10 cm) in diameter) may also have use limitations. The oversize component is unacceptable for all concrete and road-building aggregate, so must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

The other indicator of the quality of an aggregate is "lithology". Just as the unique physical and chemical properties of bedrock formations determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone, and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high-quality uses. Similarly, highly weathered, very porous and friable rock can restrict the quality of an aggregate. Deposits known to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit Symbol indicates either "C", "O", "L" or any combination, the quality of the deposit is considered to be reduced for some uses of the aggregate. No attempt has been made to quantify the degree of limitation imposed. Assessment of the four indicators is made from published data, from data contained in files of the Ontario Ministry of Transportation and Communications and the Engineering and Terrain Geology Section of the Ontario Geological Survey, and from field observations.

Analyses of unprocessed samples obtained from test holes or pits are plotted on grain size distribution graphs. On the graphs are the gradation specification envelopes for Ontario Ministry of Transportation and Communications' products: Granular Base Course (G.B.C.) A, B, and C; and Hot-Laid (H.L.) Asphaltic Sand Nos. 1, 2, 3, 4, 5, 6 and 8. By plotting the grading curves with respect to the specification envelopes, it can be determined how well the unprocessed sampled material meets the criteria for each product.

Location and Setting

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the basis of natural and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on extractive development, such as thick overburden or high water table, are less valuable resource areas, because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, powerlines, and housing developments, which are built on a deposit, may prohibit its extraction. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3.

The assessment of sand and gravel deposits with respect to local land use and to private land ownership is an important component of the general evaluation process. These aspects of the evaluation process are not considered further in this report, but readers are encouraged to discuss them with personnel of the Ontario Ministry of Natural Resources' District Office.

REGIONAL CONSIDERATIONS

In selecting sufficient areas for resource development, it is important to assess both the local and the regional resource base, and to forecast future production and demand patterns.

Some appreciation of future aggregate requirements in an area may be gained by assessing its present production levels and by forecasting future production trends. Such an approach is based on the assumptions that production levels in an area closely reflect the demand and that the present production "market share" of an area will remain roughly at the same level.

The aggregate resources in the region surrounding a municipality should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, a municipality that has large resources in comparison to its surrounding region constitutes a regionally significant resource area. Municipalities with high resources in proximity to large demand centres, such as metropolitan areas, are special cases.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data or on considerations outlined in preceding sections.

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APPENDIX B - SUGGESTED ADDITIONAL READING

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APPENDIX C - GLOSSARY

ABRASION RESISTANCE: Tests such as the Los Angeles Abrasion Test are used to measure the impact strength of aggregate. This measurement gives an idea of the breakdown that can be expected to occur when an aggregate is stockpiled, transported and placed. Hard, durable material is preferred for road building.

ABSORPTION CAPACITY: Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

AGGREGATE: Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various-sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

CLAST: An individual constituent, grain, or fragment of a sediment or rock, produced by the mechanical weathering of a larger rock mass. Synonyms include particle and fragment.

DELETERIOUS LITHOLOGY: A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregate. Such lithologies as chert, shale, siltstone, and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions.

DOLOSTONE: A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolostone is also known as dolomite).

DRIFT: A general term for all unconsolidated rock debris transported from one place and deposited in another; distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

DRUMLIN: A low, smoothly rounded, elongated hill, mound, or ridge consisting of glacial materials. These landforms were deposited beneath an advancing ice sheet, and were shaped by its flow.

EOLIAN: Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

FINES: A general term used to describe the size fraction of an aggregate which passes (is finer than) the No. 200 mesh screen (0.075 mm). Also described informally as "dirt", these particles are in the silt and clay size range.

GNEISS: A coarse textured metamorphic rock with the minerals arranged in parallel streaks or bands, but lacking schistosity. Gneiss is relatively rich in feldspar. Other common minerals found in this rock include quartz, mica, amphibole and garnet.

GRADATION: The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durability, permeability and stability of an aggregate depend to a great extent on its gradation. The industrial gradation classification for different particles is as follows:

Boulders	more than 200 mm
Cobbles	75-200 mm
Coarse Gravel	26.5-75 mm
Fine Gravel	4.75-26.5 mm
Coarse Sand	2-4.75 mm
Medium Sand	0.425-2 mm
Fine Sand	0.075-0.426 mm
Fines: Silt, Clay	less than 0.075 mm

GRANITE: A coarse-grained, light-coloured rock that ordinarily has an even texture and consists of quartz, and feldspar with either mica, hornblende or both.

GRANULAR BASE COURSE: Components of the pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability, and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C, which are usually pit-run or other unprocessed aggregate.

H.L. (HOT-LAID OR ASPHALTIC AGGREGATE): Bituminous, cemented aggregate used in the construction of pavements either as surface or bearing course (H.L. 1, 3, and 4), or as binder course (H.L. 2, 6, and 8) used to bind the surface course to the underlying granular base course.

LITHOLOGY: The description of rocks on the basis of such characteristics as color, structure, mineralogic composition, and grain size. Generally, the description of the physical character of a rock.

MAGNESIUM SULPHATE SOUNDNESS TEST: This test is designed to simulate the action of freezing and thawing on aggregate. Those aggregates which are susceptible will usually breakdown and give high losses in this test.

MELTWATER CHANNEL: A drainage way, usually terraced, produced by water flowing away from a melting glacier margin.

PETROGRAPHIC EXAMINATION: An aggregate quality test based on known field performance of various rock types. The test is a Petrographic Number (P.N.). The higher the P.N. the lower the quality of aggregate.

PLEISTOCENE: An Epoch of the recent geological past including the time from approximately 1.8 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity.

POSSIBLE RESOURCE: Estimates of mineral aggregate material based largely on broad knowledge of the geologic character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

PRECAMBRIAN: The earliest geologic period extending from the consolidation of the earth's crust to the beginning of the Cambrian.

SHALE: A fine-grained, sedimentary rock formed by the consolidation of clay, silt, or mud and characterized by well developed bedding planes, along which the rock breaks readily into thin layers. The term shale is also commonly used for fissile claystone, siltstone and mudstone.

SOUNDNESS: The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road→ uilding and construction aggregate.

TILL: Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

WISCONSINAN: Pertaining to the last glacial stage of the Pleistocene Epoch in North America. The Wisconsinan Stage began approximately 100 000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

APPENDIX D - GEOLOGY OF SAND AND GRAVEL DEPOSITS

The type, distribution, and extent of sand and gravel deposits in Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 100 000 to 7000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and can readily be differentiated on the basis of morphology, structure, and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice; and those that were deposited by meltwaters carrying materials beyond the ice margin.

ICE-CONTACT TERRACES (ICT): These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley. The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous because of extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive due to the variability of the deposits both in terms of quality and grain size distribution.

KAMES (K): Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits, producing internal structures characterized by bedding discontinuities. The deposits consist mainly of irregularly bedded and crossbedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good-quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the presence of excess fines (silt- and clay-sized particles).

ESKERS (E): Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. Eskers vary greatly in size. Many, though not all eskers consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

UNDIFFERENTIATED ICE-CONTACT STRATIFIED DRIFT (IC): This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits because of their lack of continuity and grain size variability. These deposits are given a qualitative rating based on existing pit and other subsurface data.

OUTWASH (OW): Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the glacier. Outwash deposits occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash has good horizontal bedding and is uniform in grain size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregate in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

ALLUVIUM (AL): Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and they have generally low value because of the presence of excess silt- and clay-sized material. There are no large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

GLACIOLACUSTRINE BEACH DEPOSITS (LB): These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the underlying material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear deposits, so that extractive operations are often numerous and extensive.

GLACIOLACUSTRINE DELTAS (LD): These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In Ontario, such deposits tend to consist mainly of sand and abundant silt. However, in near-ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

GLACIOLACUSTRINE PLAINS (LP): The nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt, and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources because of their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

END MORAINES (EM): These are belts of glacial drift deposited at, and parallel to, glacier margins. End moraines commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregate within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best resource areas within the moraine is usually poorly defined.

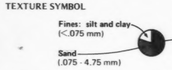
EOLIAN DEPOSITS

WINDBLOWN FORMS (WD): Windblown deposits are those formed by the transport and deposition of sand by wind. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in Ontario are derived from, and deposited on, pre-existing lacustrine sand plain deposits. Windblown sediments almost invariably consist of fine to coarse sand and are usually well sorted. The probability of locating crushable aggregate in windblown deposits is very low.

LEGEND

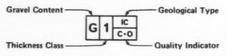
(Continued from right margin)

TEXTURE SYMBOL



The Texture Symbol provides quantitative assessment of the grain size distribution at a sampled location. The relative amounts of gravel, sand, silt and clay in the sampled material are shown graphically by the subdivision of a circle into proportional segments. The above example shows a hypothetical sample consisting of 45% gravel, 35% sand and 20% silt and clay.

DEPOSIT SYMBOL



Deposits are identified by Gravel Content, Thickness Class, Geological Type and Quality Indicator. Gravel Content is expressed as a percentage of gravel-sized material (i.e. material retained on the 4.75 mm sieve). Thickness Class is based on potential aggregate tonnage per acre. Geological Type refers to geologic origin. Quality Indicator describes objectionable grain size and lithology.

Gravel Content

G	Greater than 35% gravel.
S	Less than 35% gravel.

Thickness Class

Class	Average Thickness in Feet (Metres)	Tons per Acre	Tonnes per Hectare
1	greater than 20 (>6)	greater than 50,000	greater than 112 000
2	10 - 20 (3 - 6)	25,000 - 50,000	56 000 - 112 000
3	5 - 10 (1.5 - 3)	12,500 - 25,000	28 000 - 56 000
4	less than 5 (<1.5)	less than 12,500	less than 28 000

Geological Type

AL	Older Alluvium	**K**	Kame
E	Esker	**LB**	Lacustrine Beach
EM	End Moraine	**LD**	Lacustrine Delta
IC	Undifferentiated Ice-Contact Stratified Drift	**LP**	Lacustrine Plain
		OW	Outwash
ICT	Ice-Contact Terrace	**WD**	Windblown Forms

(see Appendix C for descriptions of Geological Types)

Quality Indicator

If blank, no known limitations present.

C	Clay and/or silt (fines) present in objectionable quantities.
L	Deleterious lithologies present.
O	Oversize particles or fragments present in objectionable quantities.

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.

Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.

Selected water well data from the Ontario Ministry of the Environment.

Test hole data from Aggregate Assessment Office, Ontario Geological Survey, Ontario Ministry of Natural Resources (see Table 4).

Terrain Evaluation by: J. F. Gartner, 1980.

Compilation and Drafting by: Staff of the Aggregate Assessment Office.

This map is to accompany O. G. S. Open File Report

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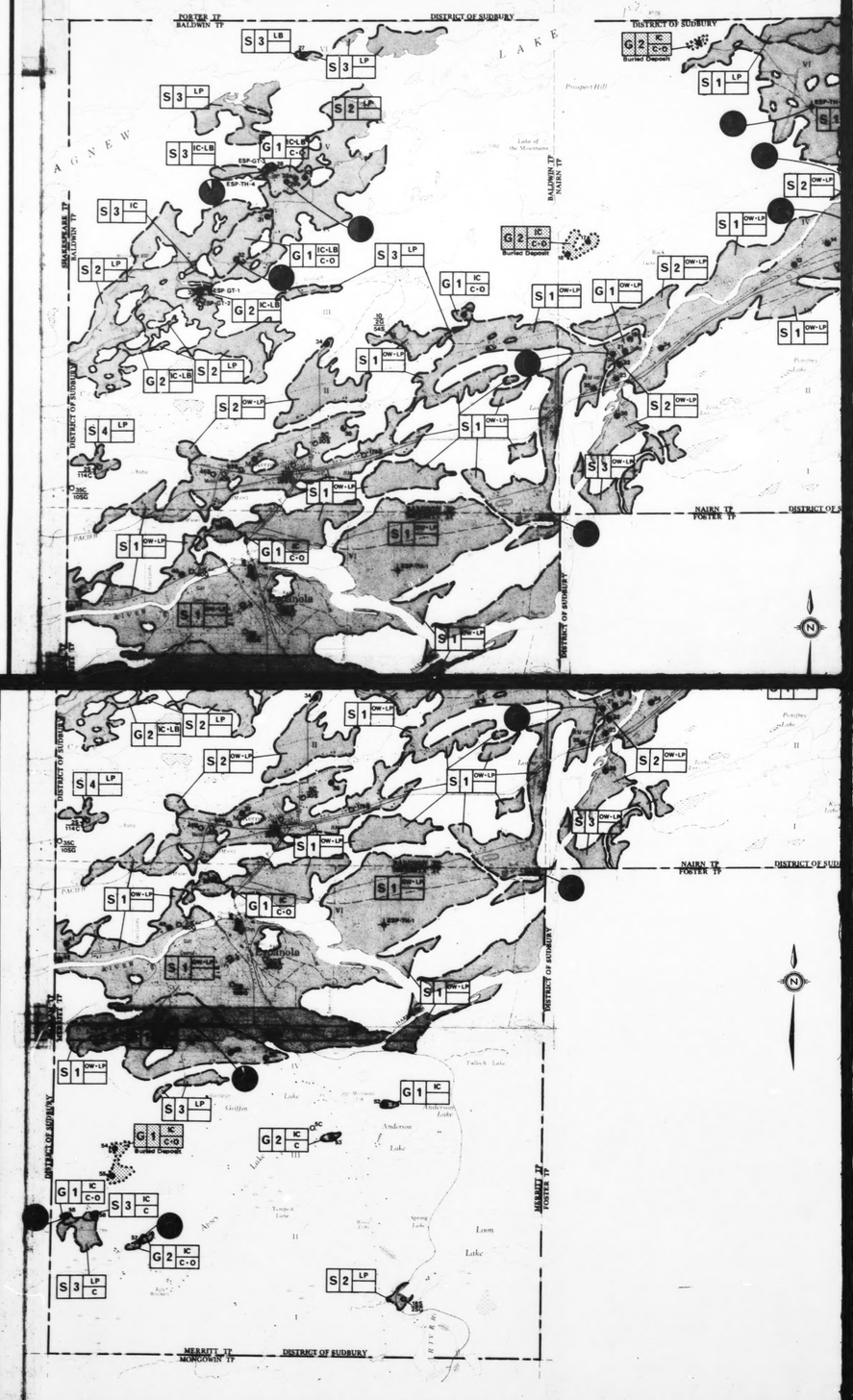
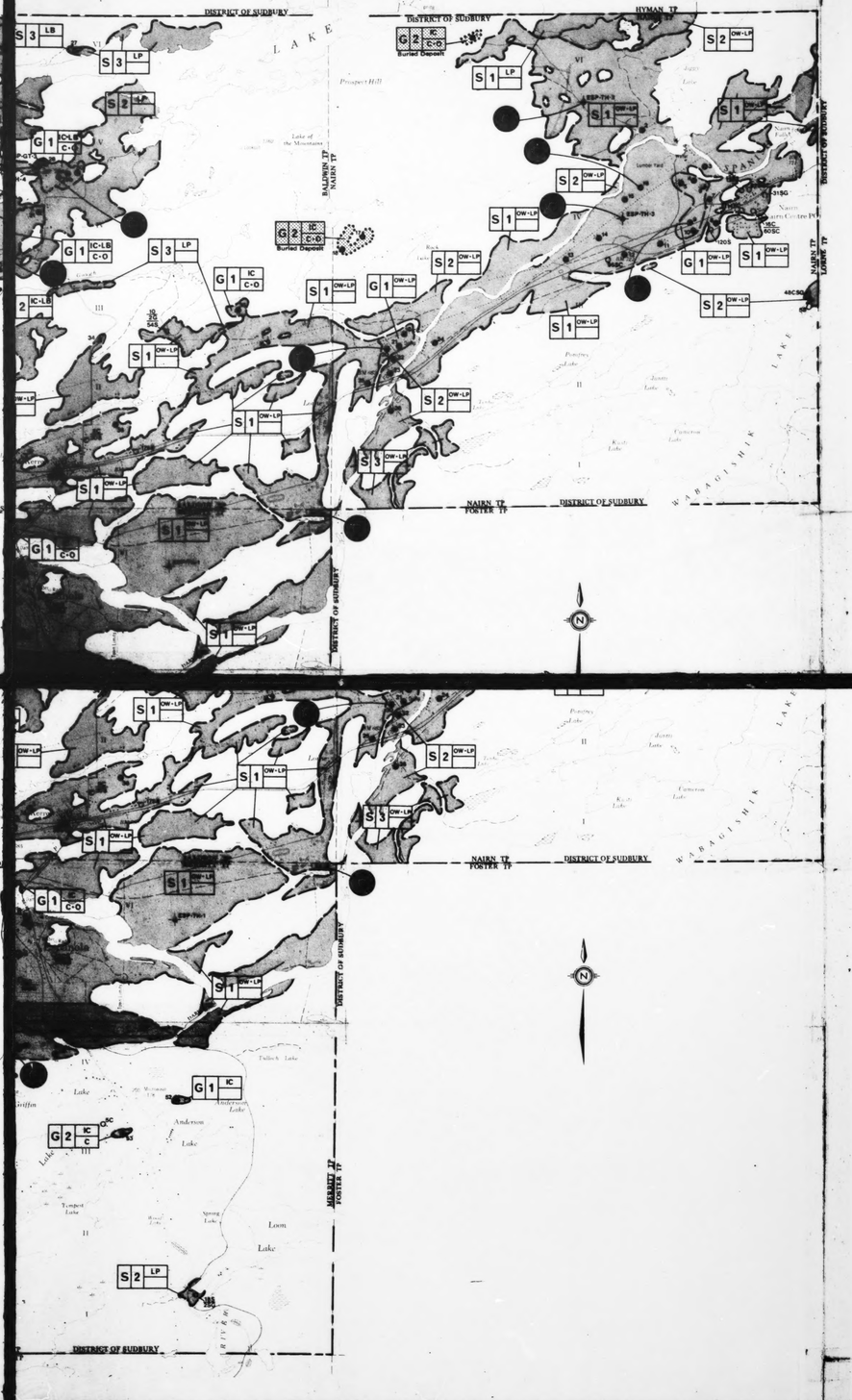
Issued 1983.

Information quoted for an individual test hole or pit refers to a specific sample or face. Care should be exercised in extrapolating such information to other parts of the deposit.





Ministry of Natural Resources — Ontario

Hon. Alan W. Pope, Minister

W. T. Foster, Deputy Minister

ONTARIO GEOLOGICAL SURVEY

AGGREGATE RESOURCES INVENTORY

ESPANOLA AREA

DISTRICT OF SUDBURY

MAP 1
DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

Scale 1: 50 000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 41 I/4, 41 I/5

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SYMBOLS

(Some symbols may not apply to this map.)

- Geological and aggregate thickness boundary. Shading indicates deposit area.
- Buried geological and aggregate thickness boundary. Shading indicates deposit area.
- Municipal boundary.
- Extracted area of sand and gravel pits.
- Sand and gravel pit; Property number: see Table 2.
- ESP-TH-2 — Selected test hole location; Identification number: see Table 4.
- Selected drilled water well location; reported thickness of material (in feet); reported type of material (number only - overburden, T - till, G - gravel, S - sand, C - clay, Bk - bedrock).
- G 1 IC C-O — Deposit Symbol: see left margin.
- Texture symbol: see left margin; see Figures
- ESP-GT-3 — Geophysical traverse line; Identification number: see Table 5.

(Continued at left margin)

Ministry of Natural Resources
Ontario

Hon. Alan W. Pope
Minister

W.T. Foster
Deputy Minister

ONTARIO GEOLOGICAL SURVEY
AGGREGATE RESOURCES INVENTORY
ESPANOLA AREA
DISTRICT OF SUDBURY

MAP 2
SELECTED SAND AND GRAVEL RESOURCE AREAS

Scale 1:50 000

Mile 1 0 1 Mile
Metres 1000 0 1 Kilometre

NTS Reference: 41 I/4, 41 I/5

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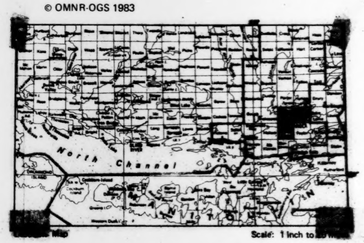

SYMBOLS

- Geological and aggregate thickness boundary.
- Buried geological and aggregate thickness boundary.
- Municipal boundary.
- Selected sand and gravel resource area; Primary significance; Deposit number: see Table 3.
- Selected sand and gravel resource area; Secondary significance.
- Selected sand and gravel resource area; Tertiary significance.
- Extracted area of sand and gravel pits.
- ●3 Sand and gravel pit; Property number: see Table 2.

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.

Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.

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